Re-Os SYSTEMATICS IN CHONDRITES AND IRON METEORITES. J. H. Chen, D. A. Papanastassiou and G. J. Wasserburg, The Lunatic Asylum of the Charles Arms Laboratory, Division of Geological and Planetary Sciences, California Institute of Technology 170-25, Pasadena, CA 91125.

Previous work [1, 2], showed a well defined correlation line on a ^{187}Re-^{187}Os evolution diagram for iron meteorites from groups IAB, IIAB, IIIAB, IVA, and IVB. In contrast, most Re-Os data on chondrites [3-6] do not define an isochron and do not plot along the well-defined iron meteorite isochron. Many chondrites plot systematically from a few permil to a few percent below the iron meteorite isochron. This disparate behavior of chondrites for the Re-Os system has required further investigation. We have initiated a study of Re-Os in chondrites. We determined the concentrations and isotopic compositions of Re and Os in two chondrites (LL and H) using the NTIMS technique. We have also obtained results on three IVA iron meteorites in order to confirm that the same techniques used on both chondrites and irons yield reliable data. IVA irons are also important for a correlation of Re-Os and Pd-Ag chronometers [7].

Irons. Following Shen *at al*. [1], samples of Seneca Township (IVA), Bristol (IVA) and Steinbach (IVA-AN) were dissolved in a sealed Carius tube with H_2SO_4, CrO_3 and a mixed ^{185}Re-^{190}Os spike. Steinbach is of particular interest as it contains silicate inclusions and may have had a different history than the typical IVA's. The results are given in Table 1 and shown in a ^{187}Re-^{187}Os evolution diagram (Fig. 1). Seneca Township and Bristol plot on the best-fit line for group IIAB irons [1]. The $\delta(^{187}Re/^{188}Os)$ values (see footnote, Table 1) are +2.3 ± 2.1 ‰ for Seneca Township and -1.3 ± 1.4 ‰ for Bristol, well within the established uncertainties. The

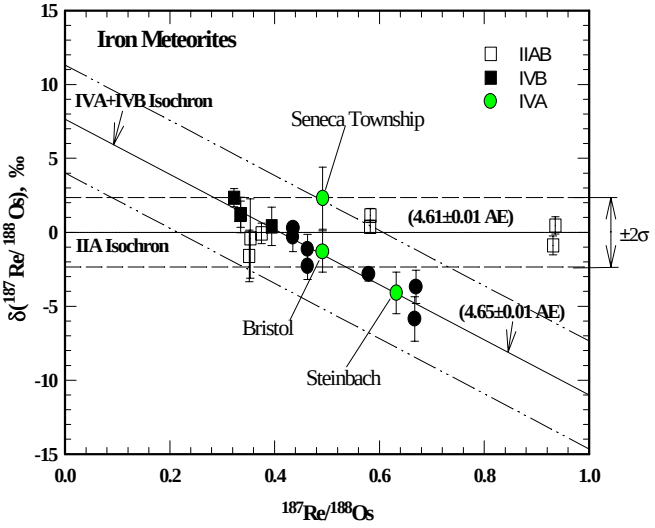

Figure 2. $\delta(^{187}Re/^{188}Os)$ vs ^{187}Re/^{188}Os diagram.

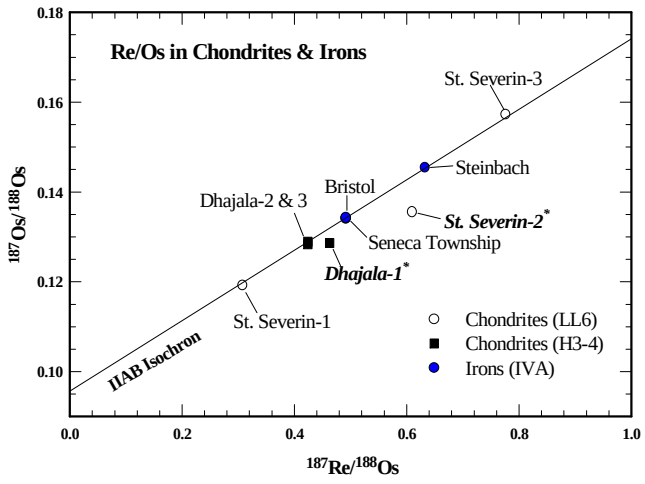

Figure 1. Re-Os evolution diagram.

Steinbach (IVA-AN) metal has lower Re and Os concentrations than the former two IVA irons, but has higher ^{187}Re/^{188}Os and ^{187}Os/^{188}Os values. In a $\delta(^{187}Re/^{188}Os)$ versus ^{187}Re/^{188}Os diagram (Fig. 2), the new Steinbach results fall slightly off the IIAB isochron, but plot along the IVA-IVB trend. Thus, our new results on IVA irons confirm the previous observation that there appears to exist a small but significant difference in age between group IIAB and IVA irons with the IVA being slightly older.

Ordinary Chondrites. To analyze the metal containing chondrites, we chose two different approaches. One was to follow exactly the procedure as used for the irons (Procedure 1). The other procedure (Procedure 2) was to place a chondrite sample first in a sealed Teflon vial with HF, HCl, ethanol and the mixed Re-Os tracer. After gently evaporating to dryness, the total residue was

introduced in a Carius tube and the Procedure-1 for the iron meteorites was then followed. Dhajala samples #2 and #3 were analyzed using Procedure 1 and yielded results in excellent agreement with each other. These lie very close to the IIAB isochron. Dhajala sample #1 (***Dhajala-1*,*** Fig. 1) was analyzed using Procedure 2 and gave greatly different concentrations and $^{187}Re/^{188}Os$, although the $^{187}Os/^{188}Os$ ratio is identical to that with Proc. 1. Two samples of St. Séverin #1 and #3 were analyzed using Proc. 1. The results from these analyses lie very close to, but not precisely on the reference isochron. They also yield widely different (32%) $^{187}Re/^{188}Os$ ratios. Sample #2 was analyzed using Proc. 2 and gave an intermediate $^{187}Re/^{188}Os$ ratio but the data lie far off the isochron (***St. Séverin-2****, Fig. 1).

DISCUSSION. While there may remain procedural problems that require clarification, it appears that the Carius technique for ordinary chondrites is yielding reasonably self-consistent results. There are two major conclusions to be drawn. Firstly, it appears that with some improvement in technique, it should prove possible to obtain precise Re-Os data on chondrites relating to early solar system history. Secondly, there is apparently a distinct behavior for Re-Os between a chondrite with low metamorphic grade (H3-4) and one of high grade (LL6). Dhajala has a uniform Re/Os close to the "solar" value, whereas different fragments of St. Séverin have Re/Os ranging by a factor of 2.5, which covers most of the observed range in Re/Os in IIAB irons. This is rather remarkable considering that the bulk meteorite is close to the solar value. The usual interpretation for PGE fractionation in Fe-Ni meteorites is that the fractionation is due to differential liquid/solid metal partitioning [8]. As the metal in chondrites is the dominant, if not exclusive carrier of PGEs, it suggests that metamorphism at the level of 6 involves the melting of FeNi and FeS and redistribution of PGEs in S-rich liquid metal during metamorphism and metal-sulfide recrystallization. We note that St. Séverin has rather large (½ cm) troilite segregations and that the metal and sulfide distributions are not uniform on the scale of centimeters. While we expect only very low concentrations of PGEs in the troilite [1], the melting of FeNi with large proportion of S could produce a S-rich melt at the eutectic with differential mechanical flow and with significant Re-Os fractionation during subsequent crystallization. Following this interpretation, it may be possible with more effort to determine the time of LL6 and H6 protoplanetary metamorphism and the minimum temperature of this metamorphism using the ^{187}Re-^{187}Os system on individual chondrites.

References. [1] Shen, J. J., Papanastassiou, D. A. and Wasserburg, G. J. (1996) *GCA* **60**, 2887-2900. [2] Smoliar, M. I., Walker, R. J. and Morgan, J. W. (1996) *Science* **271**, 1099-1102. [3] Luck, J.-M., and Allègre, C. J. (1983) *Nature* **302**, 130-132. [4] Walker, R. J. and Morgan, J. W. (1989) *Science* **243**, 519-522. [5] Walker, R. J. *et al*., (1992) *LPSC XXIII*, 1487-1488. [6] Walker, R. J. *et al*., (1993) *LPSC XXIV*, 1477-1478. [7] Chen, J. H. and Wasserburg, G. J. (1996) *Geophy. Monograph*, **95,** AGU, 1-20. [8] Jones, J. H. and Drake, M. J. (1983) *GCA* **47**, 1199-1209. Div. Cont. No. 5701(956).

Table 1. Re/Os data

Samples	Class	Wt. (g)	^{187}Re[1]	^{188}Os[1]	$^{187}Re/^{188}Os$[2]	$^{187}Os/^{188}Os$[2]	δ[3]
Irons							
Seneca Township	IVA	0.28	0.634	1.288	0.49175 ± 0.00018	0.13413 ± 0.00007	2.3 ± 2.1
Bristol	IVA	0.21	0.689	1.401	0.49156 ± 0.00023	0.13426 ± 0.00004	-1.3 ± 1.4
Steinbach	IVA-AN	0.30	0.253	0.400	0.63227 ± 0.00024	0.14546 ± 0.00005	-4.1 ± 1.4
Chondrites							
St. Séverin-1	LL6	0.22	0.071	0.219	0.30752 ± 0.00048	0.11921 ± 0.00014	23 ± 7
St. Séverin-2[4]	LL6	0.22	0.120	0.190	0.60982 ± 0.00083	0.13553 ± 0.00024	200 ± 9
St. Séverin-3	LL6	0.54	0.613	0.789	0.77632 ± 0.00063	0.15728 ± 0.00005	-12 ± 1
Dhajala-1[4]	H3-4	0.07	0.190	0.397	0.46291 ± 0.00131	0.12864 ± 0.00032	100 ± 13
Dhajala-2	H3-4	0.59	0.263	0.621	0.42400 ± 0.00030	0.12839 ± 0.00018	16 ± 7
Dhajala-3	H3-4	0.49	0.253	0.596	0.42396 ± 0.00013	0.12890 ± 0.00007	-0.1 ± 2.4

1. Re and Os concentrations in 10^{-9} moles/g. 2. All errors are 2σ.
3. $\delta = [(^{187}Re/^{188}Os)_M/(^{187}Re/^{188}Os)_{IIAB} - 1] \times 10^3$; deviation in permil of the measured data (M) from the IIAB isochron [1], by assuming that the deviation can be attributed solely to $^{187}Re/^{188}Os$.
4. Processed with Procedure 2; all others Procedure 1 (see text for details).